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Capability of Photoscreener in Detecting Refractive Anomalies in Children Aged 3–5 Years

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ABSTRACT

The aim of this study was to describe the sensitivity and specifity of the photoscreener in refractive anomaly screening of 3 to 5 year old-children. The gold standard was streak retinoscopy with cycloplegia. In the period of December 2008 to February 2009 97 children were included in this study (194 eyes), consisting of 51 girls (52.6%) and 46 boys (47.4%). The sensitivity of photoscreener for detecting refractive anomalies in children 3–5 year old was 84.11%, while the specificity was 74.71%. And the accuracy was 79.89%. The positive predictive value (PPV) was 80.36% and the negative predictive value was 79.27%. The positive likelihood ratio was 3.364 and the negative likelihood ratio was 0.211. In this study pseudo-negative was no refractive anomalies which cause amblyopia.

Key words: *photoscreener, sensitivity, spesificity, refractive errors, preschool*

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INTRODUCTION

Poor vision in childhood affects performance at school or at work and has a negative influence on the the future life of a child. Visual impairment caused by refractive error, amblyopia, strabismus, and astigmatism is a common condition among young children, affecting 5% to 10% of all preschoolers. Amblyopia is present in 1% to 4% of preschool children, an estimated 5% to 7% of preschool children have refractive errors.[1]

The frequency of refractive errors in Indonesia, generally, ranges approximately 14–20% and the most frequent is myopia.[2,3] In Indonesia, only a few data of refractive error were found among preschool children.

The most frequent causes of amblyopia are significantly uncorrected refractive errors, strabismus, or media opacities present during childhood. If the risk factors for the development of amblyopia are detected in infancy or early childhood, in principle at least, amblyopia is completely preventable. Furthermore, if amblyopia does develop, treatment is more effective in early childhood.[4]

Photoscreener is one equipment that may facilitate refractive anomaly screening in children, especially in non-cooperated children (babies, pretoddler children, and children with milestone retardation). Photoscreener can detect amblyogenic risk factors such as strabismus, significant refractive error, and media opacities; however, photoscreener cannot detect amblyopia.[5,6]

The aim of this study was to know the sensitivity and specificity of the photoscreener in refractive anomaly screening in 3–5 year old-children.

METHOD

The study was a diagnostic test, to know the sensitivity and specificity of the photoscreener to detect refractive anomaly in 3–5 year old-children. The gold standard was streak retinoscopy with cycloplegia.

The subjects of this study were 3–5 year old playgroup and kindergarten student in Yogyakarta (BOPKRI Gondokusuman Kindergarten, BOPKRI Gondolayu Kindergarten, BOPKRI Ungaran Kindergarten, and Pelangi Indonesia Kindergarten and Playgroup). The sample were taken using consecutive sampling method. Their parents had previously been informed, and agreed that

Figure 1. PhotoScreener™ System Model MTI-PS100

their children underwent examination at the dr. Yap Eye Hospital, Yogyakarta. They were examined consecutively to obtain minimum sample that fulfilled both inclusion and exclusion criteria.

Streak retinoscopy was performed twice on 20 subjects, who were previously given cyclopentolate hydrochloride 1% eye drop. The result of the reliability test was 0,875, which was classified almost perfect.

The inclusion criteria were 3–5 year old-children, no refractory media opacity, strabismus, retina anomalies or syndromes associated to refractive anomalies, severe systemic disease, allergy and contraindication shown (namely cerebral damages, history of seizure and Down syndrome), and to participate in the study. Exclusion criterion was uncooperative child during examination.

The photoscreener (PhotoScreener™ System Model MTI-PS100) examination was performed by a trained nurse. The patient was given cyclopentolate hydrochloride 1% eyedrop and a streak retinoscopy examination was carried out.

Table 1. The characteristics of subjects

Subject characteristics	Total (n = 97 subjects)
Gender	
Male	46 (47.4%)
Female	51 (52.6%)
Age	
3 years old	20 (20.6%)
4 years old	41 (41.3%)
5 years old	36 (37.1%)
History of refractive anomaly in family	
Positive	49 (50.5%)
Negative	48 (49.5%)
Other diseases found	
Allergy	2 (2.1%)
Asthma	1 (1%)
Pseudoesotropia	1 (1%)
Exophoria	1 (1%)
OS Congenital Ptosis	1 (1%)
Result of fundus examination	
OD normal	96 (99%)
OD Glaucomatous optic disc	1 (1%)
OS normal	97 (100%)

RESULT AND DISCUSSION

In the period of December 2008-February 2009, there were 97 children were included (194 eyes), consisting of 51 girls (52.6%) and 46 boys (47.4%). Among them, 20 children were 3 years old (20.6%), 41 children were 4 years old (42.3%), and 36 children were 5 years old (37.1%).

The refractive anomaly in the family was positive in 49 children (50.5%). Another anomaly that was found during the examinations were: pseudoesotropia in 1 (1%) child, exophoria in 1 (1%) child, congenital ptosis in 1 (1%) child, and the fundus examination found 1 child with glaucomatous papil (Table 1).

Refractive anomaly incidences by streak retinoscopy examination were found in 107 of 194 eyes (55.15%). They included the ones possible and not possible to cause amblyopia (Table 2). The study by Brody et al., reported refractive anomaly prevalence of 16% using definition of refractive anomalies of myopia ≥ 2D at the age of 3–4 years old and ≥ 1D at the age of > 4 years old, hypermetropia ≥ 4D at the age of 3–4 years old and ≥ 3D at the age of > 4 years old, and astigmatism ≥ 1.75D at the age of 3–4 years old, and ≥ 1.5D at the age of > 4 years old. Based on the refractive anomaly definition of the study by Brody et al., no hypermetropia anomalies was found in this study.[7] However, myopia was only found in 2 eyes (1 subject) and astigmatism was found in 13 eyes (7 subjects); hence, refractive anomaly incidences were 7.73%.

Hypermetropia was the greatest refractive anomaly, 62 of 107 (57.94%) eyes developed refractive anomalies. This was due that the age of children was between 3–5 years, where at the range of ages, hypermetropia condition was consistent with the growth of the globes. At birth, nearly 75% of infants develop hypermetropia, then emmetropization follows. At age 5–8 years they develop emmetropia.[8,9] Hypermetropia in our study was

Table 2. Result of streak retinoscopy examination

Result of streak retinoscopy examination	Total n = 97 eyes (%)
OD	
Normal	41 (42.3%)
Myopia	4 (4.1%)
Hypermetropia	32 (33.0%)
Astigmatism	20 (20.6%)
Total	97 (100%)
OS	
Normal	46 (47.4%)
Myopia	4 (4.1%)
Hypermetropia	30 (30.9%)
Astigmatism	17 (17.5%)
Total	97 (100%)

< +1.25 D; only 9 eyes (7 children) indicated hypermetropia ≥ +1.50 D and were then referred for further examinations for eyeglasses treatment. Another study defines hypermetropia when it is ≥ +4 D at the age of 3–4 years old and ≥ +3 D at the age of > 4 years old; it is because children acquire higher accommodation.[7]

Myopia among male and female subjects was similar, each were 4 eyes (3.73% of 107 eyes with refractive anomalies and 2.06% of total children examined). This was consistent with Lai's study in 2007 that among male and female children of 3–6 years, no significant difference in myopia was found. The study of Brody et al. showed that the prevalence of myopia among males and females aged 3–5 years old was 3%, while in the present study myopia prevalence was 4.12% and all of the children were referred to have further examination.[7]

If all astigmatisms were included, they were found in 37 of 107 (34.57%) eyes with refractive anomalies (19.07% of total children examined), consisting of 25 eyes among males and 12 eyes among females. In the study by Brody et al. in, the prevalence of astigmatism in the age of 3–5 years was 5.5%; however, it was when astigmatism was defined as of ≥ 1.75 D at the age of 3–4 years old and ≥ 1.5 D at the age of > 4 yeas old. When only astigmatism of ≥ 1.50 D was defined, astigmatisms in our study were found among 13 eyes (7 children); hence, astigmatism incidences were reduced to 6.7%, and the children with astigmatisms of ≥ 1.50 D were then referred for further examinations for eyeglasses.[7] Astigmatisms in the present study involved 17 eyes of myopic astigmatism, 15 eyes of hypermetropic astigmatism and 5 eyes of mixed astigmatism. Anisometropia occured among 4 male children (4.1%), where 3 children showed differences of ≥ 1.25 D and 1 child of < 1.25 D.

Based on diagnostic test to assess refractive anomalies using photoscreener and streak retinoscopy, it was found that both instruments showed 90 eyes were positive for refractive anomalies and 65 eyes were not. Streak retinoscopy stated that 17 eyes developed refractive anomalies, but photoscreener (pseudo-negative) did not. Photoscreener stated that 22 children positively developed refractive anomalies, but streak retinoscopy (pseudo-positive) did not, as seen on Table 3 and 4.

Table 3. 2 × 2 table of the results photoscreener examination and streak retinoscopy in detecting refractive error in children aged 3–5 years.

		Streak retinoscopy examination		
Photoscreener examination	**Refractive error**	**+**	**–**	**Total (eyes)**
	+	90	22	112
	-	17	65	82
	Total	107	87	194

The sensitivity and specificity photoscreener were 84.11% and 74.71%. Our hypothesis stated that sensitivity was 80% and specificity was 90%. It was based on the previous studies,[4,10,11] and lower prevalence. Therefore, specificity test was more important than sensitivity test.[12] However, for the screening purpose, the prevalence of disease should be moderately high (hence, sensitivity test was more important), and the present study was to perform early detection or screening at the age of 3–5 years old.

Table 4. Results of some diagnostic test indicator from 2 × 2 table

Diagnostic indicator	Values (%)
Sensitivity	84.11
Specificity	74.71
Positive predictive value	80.36
Negative predictive value	79.27
Accuracy	79.89
Positive likelihood ratios	3.364
Negative likelihood ratios	0.211

Guo *et al*. in 1999 in Guangzhou, China compared the computerized-photoscreener and non-cycloplegic retinoscopy for amblyogenic risk factor in 9–50 month old-children. The sensitivity of the computerized photoscreener was 94.6%, while the specificity was 90.1%. The sensitivity of the non-cycloplegic retinoscopy was 85.7% and the specificity was 81.0%.[4]

Cogen and Ottemiller, in 1992 in Birmingham, performed a study using Visiscreen, in children younger than 3 years old, overall sensitivity and specificity were 85% and 94%.[10]

Kennedy, *et al*. in 1995 in Canada evaluated the accuracy of Snellen E-test or Stycar balls in different size and Titmus Fly Stereotest, among 3 to 5 year-old children, and reported predicting sensitivity of 9–12.5% and specificity of 99%.[13]

In Canada, Robinson and friends, in 1999 conducted a qualified research among 3–5 years old children by nurses with some tests, Crowding Cambridge card, Hirschberg

Table 5. Diagnostic test indicators for each refractive error

	Overall refractive errors	Myopia	Hypermetrop	Astigmatism
Sensitivity (%)	84.11	50	54.8	59.5
Specificity (%)	74.71	95.7	91.7	80
Positive predictive value (%)	80.36	33.3	75.5	40
Negative predictive value (%)	79.27	97.8	81.2	89.2
Accuracy (%)	79.89	93.8	79.9	75.3
Positive likelihood ratios	3.364	11.628	6.626	2.857
Negative likelihood ratios	0.211	0.522	0.489	0.512

test, and Titmus Fly Stereotest, reporting overall sensitivity 60–71% dan specificity 70–80%.[14]

Tong, *et al.* in 1998 and 2000 in Maryland, USA, also Coper and friends in 1999 in Australia, calculated the accuracy of photoscreener Medical Technology Incorporated (MTI) in children population younger than 3 years old with high prevalence of visual impairment and obtained sensitivity between 40–88%.[15,16,17]

All of the previous studies used MTI photoscreener to detect all ambliogenic factors. Our study performed photoscreener MTI only to detect refractive anomalies.

For each refractive anomaly, photoscreener showed the highest sensitivity of 59.5% in astigmatism with specificity of 80%, while the highest specificity was 95.7% during myopia examination, with sensitivity of 50%. Therefore, it was concluded that photoscreener was better in detecting astigmatism and removing myopia refractive anomalies (Table 5).

Pseudo-negatives were found in 17 (8.76%) eyes and pseudo-positive were found in 22 (11.34%) eyes. The causes of pseudo-negative were hypermetropia in 12 eyes and astigmatism in 5 eyes (Table 6).

Table 6. The causes of pseudo-negative

Causes	Total (%)
Hypermetropia	12 (70.59)
Astigmatism	5 (29.41)

The causes of pseudo-positive were hypermetropia in 8 eyes and astigmatism in 14 eyes. This was affected by less appropriate focus on pupil; hence, during photo assessment, highly thin crescent-shape was present in pupil and was subsequently considered as hypermetropia and astigmatism (Table 7).

Table 7. Causes of peudo-positive

Causes	Total (%)
Hypermetropia	8 (36.36)
Astigmatism	14 (63.64)

To date no test instrument has been found as providing pseudo-negative and pseudo-positive values. The causes of pseudo-negative were hypermetropia in 12 eyes (7 children) and astigmatism in 5 eyes (3 children). Photoscreener-based examination was conducted without cycloplegic, while streak retinoscopy-based examination was carried out following cycloplegic application. This led to latent hypermetropia detection.[17] Hypermetropia which is likely to cause amblyopia was ≥ +2.75 D or crescent size in photo ≥ 2 mm.[4] Hypermetropia producing pseudo-negative ranged from + 0.25D to +1.00D. Based on such a condition, pseudo-negative was not hypermetropia which was likely to cause amblyopia. Astigmatism which was the risk factor of amblyopia was ≥ 1.75D[4], while the greatest difference of astigmatism causing pseudo-negative in the present study was 0.75D; hence, it did not cause amblyopia.

CONCLUSION

The sensitivity and specificity photoscreener in the screening of refractive anomalies at the age of 3–5 years was 84.11% and 74.71% respectively.

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